

Recommendations for a DFO Maritimes Coastal Monitoring Program

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CONTENTS

ABSTRACT.....	iv
RÉSUMÉ	iv
EXECUTIVE SUMMARY	v
INTRODUCTION	1
PRELIMINARY FRAMEWORK	2
PROGRAM BOUNDARIES	2
REPRESENTATIVE SUB-REGIONS.....	2
GAPS, NEEDS, AND OPPORTUNITIES.....	3
DRIVERS, PRESSURES, AND INDICATORS	5
SAMPLING TECHNIQUES THAT ACCOUNT FOR SPATIAL AND TEMPORAL VARIABILITY	6
KEY ELEMENTS AND PROGRAM MILESTONES	6
KEY ELEMENT 1: SUPPORT FOR PROGRAM COORDINATION AND GOVERNANCE.....	7
KEY ELEMENT 2: SUPPORT FOR PROGRAM DEVELOPMENT AND SUSTAINED OBSERVATIONS	9
KEY ELEMENT 3: SHORT- AND LONG-TERM PROGRAM OBJECTIVES	11
KEY ELEMENT 4: SUPPORT AND INFRASTRUCTURE FOR DATA MANAGEMENT	13
KEY ELEMENT 5: SUSTAINED ENGAGEMENT OF RESEARCH SCIENTISTS IN DATA ANALYSIS AND SYNTHESIS	14
KEY ELEMENT 6: REGULAR, CREDIBLE, AND CLEAR PROGRAM REPORTING	15
KEY ELEMENT 7: COMMUNICATION AND COLLABORATION AMONG RESEARCH SCIENTISTS, RESOURCE MANAGERS, AND STAKEHOLDERS	16
KEY ELEMENT 8: PERIODIC ASSESSMENT OF THE PROGRAM	16
GENERAL RECOMMENDATIONS	17
ACKNOWLEDGEMENTS	18
REFERENCES	18
APPENDIX 1: DRIVERS AND PRESSURES IN THE MARITIMES REGION COASTAL ZONE	21
APPENDIX 2: PARTICIPANTS IN PRE-WORKSHOP CONSULTATIONS	24
APPENDIX 3: QUESTIONS USED TO GUIDE CONSULTATIONS (OCT–DEC 2015)	25
APPENDIX 4: TERMS OF REFERENCE FOR COASTAL MONITORING WORKSHOP	27
APPENDIX 5: PARTICIPANTS IN COASTAL MONITORING WORKSHOP	29

ABSTRACT

DiBacco, C., Johnson, C.L., Moore, A.M., and Scriven, D.R. 2016. Recommendations for a DFO Maritimes Coastal Monitoring Program. Can. Tech. Rep. Fish. Aquat. Sci. 3185: viii + 29 p.

In support of a DFO Maritimes regional coastal monitoring initiative, we developed a preliminary framework, identified key elements and program milestones, and highlighted general recommendations to inform its implementation. Advice was generated using best available data and expert knowledge synthesized from a literature review, initiation of a DFO Maritimes Coastal Monitoring Inventory, and consultations and a workshop with coastal researchers, managers, and stakeholders. Seven milestones were selected for immediate action to address program development priorities. Overall, there is great interest and opportunity to integrate and develop existing monitoring in the region to more efficiently monitor change in the coastal zone. However, support for coastal monitoring coordination, direction from a steering committee, and coastal data management processes are necessary to provide the infrastructure required to efficiently add new coastal observations and incorporate them into data management, data analysis, and advice.

RÉSUMÉ

DiBacco, C., Johnson, C.L., Moore, A.M., and Scriven, D.R. 2016. Recommendations for a DFO Maritimes Coastal Monitoring Program. Rap. tech. Can. sci. halieu. Aquat. 3185: viii + 29 p.

En vue d'appuyer un programme dans la région des Maritimes de surveillance côtière, nous avons développé un cadre préliminaire, des éléments clés, des étapes du programme et des recommandations générales pour étayer sa mise en oeuvre. Des avis ont été publiés se fondant sur les meilleures données disponibles, les connaissances d'experts dégagées à partir d'une analyse documentaire, de la tenue d'un inventaire du programme de surveillance côtière du MPO, région des Maritimes, et de consultations de même qu'un atelier avec des chercheurs, des gestionnaires et des intervenants en zone côtière. Sept étapes ont été sélectionnées aux fins de mesures immédiates pour répondre aux priorités de l'élaboration du programme. Dans l'ensemble, il y a un grand intérêt et une excellente possibilité d'intégrer des mécanismes de surveillance existants et d'en élaborer d'autres dans la région pour surveiller les changements en zone côtière de manière efficace. Par conséquent, le soutien à la coordination de la surveillance côtière, l'orientation d'un comité directeur et les processus de gestion des données côtières sont indispensables à l'obtention d'infrastructures qui occasionneront de nouvelles observations côtières plus efficaces et incorporées à la gestion des données, à l'analyse des données et à la diffusion d'avis.

EXECUTIVE SUMMARY

BACKGROUND

- In October 2015, DFO Maritimes Coastal Ecosystem Science Division (CESD) was tasked with providing recommendations for a DFO Maritimes Region (hereafter DFO Maritimes) coastal monitoring program.
- There is regional and national interest in developing such a program because the coastal zone is a productive, active, and changing environment affected by multiple human- and climate-driven pressures, and baseline and ongoing observations from monitoring help managers make informed decisions about resource use and management.
- There is also an opportunity to integrate and develop existing monitoring in the region to more efficiently monitor change in the coastal zone and how it affects biodiversity and other components of the environment.
- To enhance coastal monitoring in the Maritimes Region, CESD developed a **preliminary framework, key elements and program milestones**, and **general recommendations** as DFO Science advice for development of a DFO Maritimes coastal monitoring program.
- Advice was generated using best available data and expert knowledge synthesized from a literature review on monitoring programs, initiation of a DFO Maritimes Coastal Monitoring Inventory, and consultations and a workshop with coastal researchers, managers, and stakeholders.
- This report aims to provide a foundation and vision for development of a regional, possibly national, framework through consultation with DFO experts and prospective users to optimize current and future monitoring efforts and investment to generate valuable data and data products.

PRELIMINARY FRAMEWORK

- To provide comprehensive coverage from coast to shelf, coastal zone onshore-offshore boundaries were recommended, respectively, as the high-tide mark and the 100 m isobath (the inshore limit of the DFO Research Vessel Trawl Survey located 11 to 22 km offshore).
- Nine coastal sub-regions along the Maritimes coasts identified in work by Greenlaw (in press) are recommended as a starting point for defining representative sub-regions on which to base an initial monitoring design.
- Existing monitoring programs (e.g., Long-Term Temperature Monitoring Program, DFO Aquatic Invasive Species Monitoring Program) should be leveraged to expand fundamental indicator monitoring (i.e., temperature, salinity) and new high-priority observations (e.g., nutrient loading, dissolved oxygen, turbidity) in the short term. DFO's role (i.e., coastal monitoring efforts along with current AZMP representation) may also be expanded in coordination with

international efforts, including the Integrated Sentinel Monitoring Network for Change in Northeast U.S. Ocean and Coastal Systems (ISMN) initiative (www.neracoos.org/sentinelmonitoring/database) to contribute to and help create a more efficient and integrated monitoring program on a larger scale.

- Four environmental drivers in the DFO Maritimes coastal zone were identified and their associated pressures were ranked (top two pressures per driver are listed here, see Appendix 1 for the complete list):
 - **Climate change:** warming temperatures; ocean acidification
 - **Coastal development:** habitat or biodiversity loss and degradation; aquatic invasive species
 - **Coastal pollution:** nutrient loading, eutrophication, dissolved oxygen, and dead zones; runoff
 - **Resource exploitation:** not identified, see Table 2; Appendix 1
- To provide high-quality data in a cost-effective manner, the most appropriate temporal and spatial scales of variability must be identified to establish optimal sampling frequency and methodology for each variable.

KEY ELEMENTS AND PROGRAM MILESTONES

- Eight **key elements** and associated **short-term milestones (STMs: Years 1–5)** and/or **medium-term milestones (MTMs: Years 3–10)** were identified to address three priorities in developing a DFO Maritimes coastal monitoring program: **building a foundation**, **stabilizing existing resources**, and **growing the program**. See Table 1 for a summary of milestones for each key element and program priority.

GENERAL RECOMMENDATIONS

- The seven milestones identified in bold in Table 1 should be considered for immediate action to build on this report and address program development priorities.
- An effective and valuable coastal monitoring program should engage and support research scientists, resource managers, and stakeholders working in the coastal zone (e.g., aquaculture; aquatic invasive species; habitat management and conservation planning; energy resource development and management).
- Optimization of monitoring in the coastal zone requires DFO to coordinate work by government, universities, non-governmental organizations (NGOs), and other stakeholders to develop baseline observations and identify the impact of pressures most relevant to research scientists and resource managers.
- Support for coastal monitoring coordination, direction from a steering committee, and coastal data management processes are necessary to provide the infrastructure required to efficiently add new coastal observations and incorporate them into data management, data analysis, and advice.

Table 1. Key elements and associated short-term milestones (STMs) and medium-term milestones (MTMs) for development of a DFO Maritimes coastal monitoring program. See Key Elements and Program Milestones section for milestone descriptions. STMs in bold are recommendations for immediate action (see General Recommendations) and those marked with * were part of this report.

		KEY ELEMENTS							
		1. Support for program coordination and governance	2. Support for program development and sustained observations	3. Short-term and long-term program objectives	4. Support and infrastructure for data management	5. Sustained engagement of research scientists in data analysis and synthesis	6. Regular, credible, and clear program reporting	7. Communication and collaboration among research scientists, resource managers, and stakeholders	8. Periodic assessment of the program
PROGRAM PRIORITIES	Building a foundation	* STM 1A: Provide recommendations for a monitoring program STM 1B: Establish a steering committee STM 1C: Initiate FTE support for program coordination STM 1D: Develop program governance	* STM 2A: Initiate DFO Maritimes Coastal Monitoring Inventory STM 2B: Identify budgetary support for program development, initiation, implementation, and maintenance	* STM 3A: Initiate consultations and workshops STM 3B: Develop short- and long-term program objectives	STM 4A: Develop data management plan for existing observations and identify budgetary support STM 4B: Develop data management plan for new observations	STM 5A: Identify core group of research scientists	STM 6: Establish program reporting goals	STM 7: Develop and implement a communication plan	
	Stabilizing existing resources		STM 2C: Expand DFO Maritimes Coastal Monitoring Inventory	↑	STM 4C: Publish DFO Maritimes Coastal Monitoring Inventory online				
	Growing the program	MTM 1: Coordinate with coastal monitoring initiatives in other DFO Regions	STM 2D: Initiate new monitoring via existing program expansion and pilot projects STM 2E: Identify new high-priority monitoring observations	STM 3C: Continue consultations and workshops ↓		STM 5B: Develop data products MTM 5: Identify support for data analysis and synthesis	MTM 6: Initiate peer-reviewed program reporting	MTM 7: Establish program website	MTM 8: Assess progress and re-evaluate program requirements

INTRODUCTION

In October 2015, DFO Maritimes Coastal Ecosystem Science Division (CESD) was tasked with providing recommendations for a DFO Maritimes coastal monitoring program. Coastal ecosystems are productive systems that support commercial and recreational activities and human population growth near the coasts worldwide (Mann 2000), and they are economically, socially, and culturally valuable. Nearshore coastal ecosystems and habitats are affected both by human uses such as commercial activities (e.g., shipping, aquaculture), resource use (e.g., fisheries, oil and gas extraction), and habitat change (e.g., seawall construction, harbour dredging) as well as climate-driven pressures such as sea surface warming and sea level rise. Together, these human- and climate-driven pressures can interact to accelerate changes to the ecosystem such as eutrophication or susceptibility to aquatic invasive species (AIS).

Long-term coastal monitoring produces baseline data and ongoing observations that help quantify such changes in coastal ecosystems (Strain and Macdonald 2002) and how human- and climate-driven pressures interact to affect biodiversity and other components of the environment. Thus far, sustained monitoring of the coastal zone by DFO Maritimes and knowledge of coastal processes (e.g., food web dynamics for fish and species at risk) has been limited (Gibbs 2013). Nonetheless, there is currently interest and opportunity in developing a coordinated coastal monitoring program that will integrate and develop existing monitoring efforts in the region (e.g., AIS, aquaculture, marine protected areas) to more efficiently monitor change in the coastal zone. Uses of data from a coastal monitoring program could include identifying baselines, trends and unusual or extreme events, parameterizing and testing environmental models, projecting the rate and magnitude of climate change, and providing context to short-term experiments and observations (Lovett et al. 2007). This information is critical for making informed decisions in multiple programs, including sustainable resource use (e.g., predicting recruitment success and allowable fishing quotas based on temperature time-series), marine conservation management (e.g., establishing indicators for evaluating effectiveness of marine protected areas), and environmental stressor reporting (e.g., baseline data for providing advice to clients, such as Fisheries Protection Program).

This report reflects Science advice to develop a monitoring program for DFO Maritimes and was generated using best available data and expert knowledge synthesized from a literature review on monitoring programs, initiation of a DFO Maritimes Coastal Monitoring Inventory, and consultations and a workshop with coastal researchers, managers, and stakeholders. Advice is summarized into three sections: a **preliminary framework**, **key elements and program milestones**, and **general recommendations**. Together this advice provides a foundation of knowledge and expertise and a direction for implementing a successful DFO Maritimes coastal monitoring program that incorporates and optimizes current resources and facilitates program growth.

PRELIMINARY FRAMEWORK

Coastal monitoring programs are shaped by the nature of the coastal zone itself, which can be complex and therefore described, defined, and monitored in different ways. Designing a comprehensive and achievable monitoring program in the heterogeneous and diverse nearshore coastal ecosystem is challenging and requires a basic framework from which the program can be effectively developed. Here we summarize recommendations (based on consultations and workshop discussions) with regards to five fundamental aspects of a coastal monitoring program: program boundaries; representative sub-regions; gaps, needs, and opportunities; drivers, pressures, and indicators; and sampling techniques that account for temporal and spatial variability.

PROGRAM BOUNDARIES

The shoreward boundary of the coastal zone in the Maritimes Region was accepted as the high tide mark by workshop participants; however, the seaward limit required further consideration. Previous DFO work defined the seaward extent of the coastal zone as the 10 to 30 m depth contour, depending on jurisdiction and regional bathymetry (e.g., Butler et al. 1996); newer DFO work (Greenlaw et al. 2012) defined the limit as the inshore limit of the DFO Research Vessel Trawl Survey (about 22 km offshore and at approximately 100 m depth). The inshore limit of the AZMP monitoring transects is similar (11 to 22 km offshore), with inshore station depths between 80 and 100 m. Although constraining coastal monitoring efforts to the 10 to 30 m depth contour (<2 to 3 km from shore) would fulfill the coastal zone working definition, it results in a gap in coverage in the coastal shelf transition areas between the coast and the offshore trawl survey and AZMP monitoring area (Figure 1). The offshore and coastal zones do not function independently, so it is important to monitor indicators of physical, chemical, and biological processes in regions that link the two. Because monitoring in this coastal shelf transition zone is necessary to describe and understand oceanographic processes that link nearshore and offshore ecosystems (e.g., coastal upwelling, internal wave propagation), using the inshore limit of the DFO Research Vessel Trawl Survey as the boundary (Greenlaw et al. 2012) was considered preferable. In addition, this boundary is currently used for marine protected area (MPA) and ecologically or biologically significant marine area (EBSA) planning and would better position the monitoring program to contribute to such efforts in coastal and offshore regions.

REPRESENTATIVE SUB-REGIONS

The Maritimes Region coastal zone is particularly complex topographically and oceanographically (Figure 1), therefore defining coherent areas into representative sub-regions for monitoring is important to help assess spatial variability and heterogeneity. Characteristic sub-regions define areas that can be represented by a manageable number of monitoring stations to reduce sampling effort. Greenlaw (in press) identified nine sub-regions for the Maritimes Region based on physical and chemical components of the coastal system (Figure 2); the analysis did not include biological data as they were not comprehensive enough for this assessment (M. Greenlaw, pers. comm.). MPA and EBSA planning groups currently use these sub-regions, and employing the same

underlying zonation in a coastal monitoring program would facilitate integration and coordination with conservation planning in the region. These nine sub-regions are therefore recommended as a starting point for a coastal monitoring program; as additional data become available (STM 2D, STM 2E), the coastal sub-regions and coherence may be reassessed during future consultations and workshops (STM 3C).

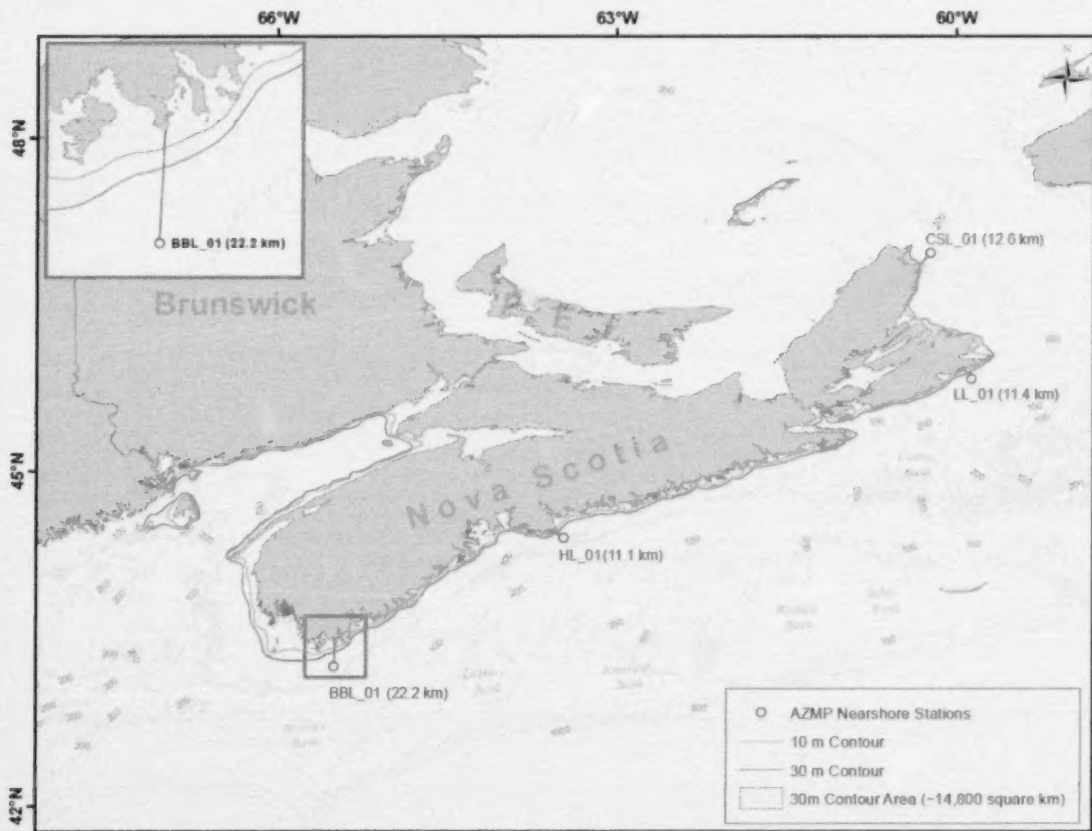


Figure 1. Depth contour lines (10 m and 30 m) in the DFO Maritimes Region. Nearshore stations (yellow dots) of four AZMP monitoring transects are overlain to depict the monitoring gap between AZMP monitoring and the 30 m contour. Monitoring transects shown are Browns Bank Line (BBL), Halifax Line (HL), Louisbourg Line (LL), and Cabot Strait Line (CSL). Figure courtesy A. Cogswell.

GAPS, NEEDS, AND OPPORTUNITIES

The DFO Maritimes Coastal Monitoring Inventory (see STM 2A) was initiated to review spatial and temporal coverage of existing monitoring and research programs and to help identify basic gaps, needs, and opportunities in the Maritimes Region. Overall, there is an opportunity to leverage existing monitoring programs (i.e., Long-Term Temperature Monitoring Program (LTTMP), DFO Aquatic Invasive Species Monitoring Program) to expand fundamental indicator monitoring (i.e., temperature, salinity) and add new

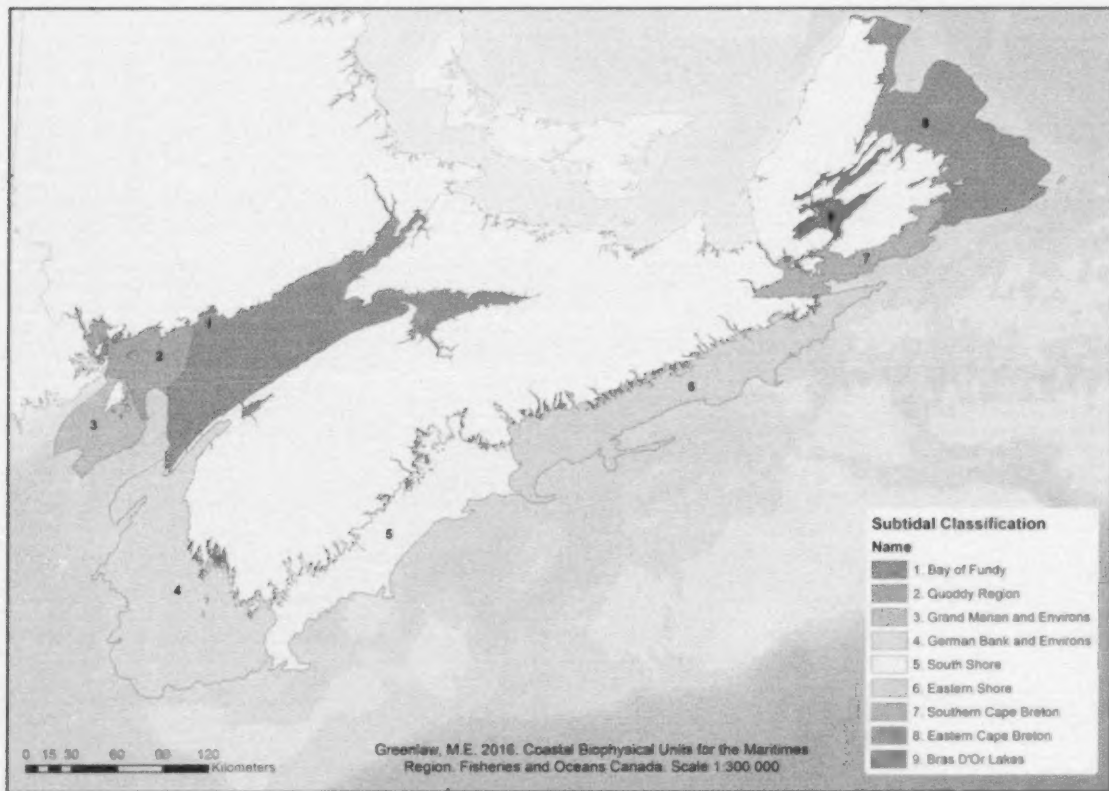


Figure 2. Nine coastal sub-regions in DFO Maritimes recommended as a starting point for defining representative sub-regions on which to base an initial coastal monitoring design. Modified from Greenlaw (in press).

high-priority observations in the short term (see Appendix 1 for ranked pressures and indicators). For example, the LTTMP could be expanded to include salinity and to target sampling gaps in proposed coastal sampling sub-regions. At present, many historical coastal datasets (e.g., seagrass distribution, fish biodiversity) are not included in the inventory because the data is inaccessible (i.e., not archived, hard copy only). This is a particularly urgent concern given recent and imminent retirement of many research scientists in the region. Expanding the inventory (STM 2C) to include these existing datasets with potential for renewed monitoring would be particularly useful to identify gaps and link new observations with historical data.

Inventory and indicator-based methodology development should be coordinated with the Integrated Sentinel Monitoring Network for Change in Northeast U.S. Ocean and Coastal Systems (ISMN), which has completed and published a review of standard methodologies and established a data management framework for hosting data from multi-regional and institutional partners. DFO's role (i.e., coastal monitoring efforts in conjunction with current AZMP representation) may also be expanded with the ISMN initiative (www.neracoos.org/sentinelmonitoring/database) to contribute to and help create a more efficient and integrated monitoring program on a larger scale.

DRIVERS, PRESSURES, AND INDICATORS

Ideally, a coastal monitoring program should provide observations that inform high-priority drivers and pressures and their impact on the system under study. One goal of consultations and workshops was to identify these environmental drivers and pressures, especially those relevant to management issues (e.g., EBSA and MPA planning) and coastal processes vulnerable to change (e.g., species and habitats at risk, commercial stock and ecosystem sustainability, threats to biodiversity). Four environmental drivers (causes of environmental change) and multiple driver-associated pressures (results of environmental change) were identified for the Maritimes Region coastal zone (Table 2). Pressures were then ranked based on expert opinion of their perceived risk and relevance to a monitoring program in the region. Many of the listed pressures could be categorized under multiple drivers (e.g., runoff is important to both coastal development and coastal pollution); however, to simplify the exercise, each pressure was ranked for one driver. Further discussions should consider pressures under all relevant drivers. Ideal indicators for monitoring are measurable, accurate, sensitive, and responsive (OECD 2003; Rice 2003). Relevant indicators for the region were also identified for each pressure, including how those indicators are currently monitored and how they might be monitored in the future (Appendix 1).

Table 2. Key coastal environmental drivers (causes of environmental change) and pressures (results of environmental change) identified and ranked (1 = highest ranked; 5 = lowest ranked) during consultations.

Driver	Rank	Pressure
Climate change	1	Warming temperatures
	2	Ocean acidification
	3.5	Salinity
	3.5	Sea level rise (including storm surges)
	5	Ice cover
Coastal development	1	Habitat or biodiversity loss and degradation
	2	Aquatic invasive species
	3.5	Water quality (including turbidity)
	3.5	River inflow, sedimentation and erosion processes, and sediment transport
	5	Industrial use, and coastal development and urbanization
Coastal pollution	1	Eutrophication, dissolved oxygen, dead zones, and nutrient loading
	2	Runoff
	3	Contaminants (including oil spills)
	4	Pathogens and disease
	5	Marine debris (including microplastics)
Resource exploitation	Further consultation with established programs (i.e., Program for Aquaculture Regulatory Research, DFO Population Ecology Division) is required to avoid overlap of divisional mandates and duplication of monitoring efforts.	

SAMPLING TECHNIQUES THAT ACCOUNT FOR SPATIAL AND TEMPORAL VARIABILITY

Spatial variability in coastal zones reflects multi-scale geographic variation in nearshore processes. For example, variation in regional tidal extent (e.g., Bay of Fundy vs. southern coast of Nova Scotia), marine habitat diversity (e.g., intertidal vs. subtidal, planktonic vs. benthic), and terrestrial effects mediated by regional watershed characteristics and associated runoff (e.g., nutrient loading, eutrophication) leads to significant spatial variability. Physical processes such as tidal cycles and input from terrestrial ecosystems via precipitation and runoff also impart considerable temporal variability (e.g., semi-diurnal/diurnal to seasonal), which affects both abiotic factors (e.g., temperature, salinity, turbidity, dissolved oxygen, pH) and biotic factors (e.g., primary and secondary productivity, species, community, habitat, and ecosystem diversity). Further, productivity of coastal ecosystems is enhanced by benthic–pelagic coupling in shallow nearshore environments, which facilitates the exchange and cycling of nutrients via organism movement, trophic interactions, and biogeochemical cycling (e.g., Anderson and Polis 2004; Baustian et al. 2014).

To monitor such highly variable abiotic and biotic factors requires sampling methodologies that specifically account for this variability. Sampling strategies can vary from high-frequency/low-intensity to low-frequency/high-intensity depending on the nature of the factor being measured and equipment cost, availability, reliability, and viability. Sampling frequency must be appropriate for the dominant temporal scale of variability in the process being measured: **continuous (<hourly)** for indicators that vary on short time and spatial scales (e.g., temperature, salinity, current velocity, and sea level); **daily, weekly, or monthly** for indicators that vary spatially and on a seasonal scale (e.g., turbidity, pH, dissolved oxygen); **annual** for indicators that do not vary on short time scales and require considerable sampling effort (e.g., planktonic and benthic biomass); and **multiannual** for indicators with low expected rate of change (e.g., biodiversity of communities in coastal ecosystems, distribution and abundance of biologically sensitive habitats).

KEY ELEMENTS AND PROGRAM MILESTONES

Monitoring programs are as diverse in scope and purpose as are the systems they monitor; however, successful programs have many features in common. We identified eight **key elements** of successful monitoring programs, contextualized their importance to the Maritimes Region, and developed **short-term milestones (STMs: Years 1–5)** and/or **medium-term milestones (MTMs: Years 3–10)** for each key element to assess progress under three program priorities: building a foundation, stabilizing existing resources, and growing the program (Table 1). **Long-term milestones (LTMs)** (e.g., program re-assessment, development of system models), while critical for program success, were not specified here as they are expected to be developed by the steering committee once the program has operated for at least 5 to 10 years.

KEY ELEMENT 1: SUPPORT FOR PROGRAM COORDINATION AND GOVERNANCE

Program coordination and governance of monitoring activities is particularly important in coastal monitoring as coastal waters are highly accessible. Activities of various groups (e.g., government, universities, non-governmental organizations, community-based science, First Nations, general public) are often focused in common locations, and coastal issues have high public engagement. Support to communicate and coordinate with such regional groups on establishing complementary sampling programs and standardizing methods, data management processes, and accessibility would greatly increase the overall efficacy of a monitoring program. Coordination among DFO regions would promote continuity, compatibility, and comparability in sampling design, methodology, and integrated reporting at a larger scale.

An effective collaborative model for program coordination and governance across four DFO regions on Canada's Atlantic coast has been developed by AZMP (Figure 3). Replicating this model in a new coastal monitoring program would require a substantial commitment of time and effort by coastal researchers and resource managers to ensure that annual program deliverables (e.g., data collection, management, analysis, interpretation, and reporting) are met in a timely manner.

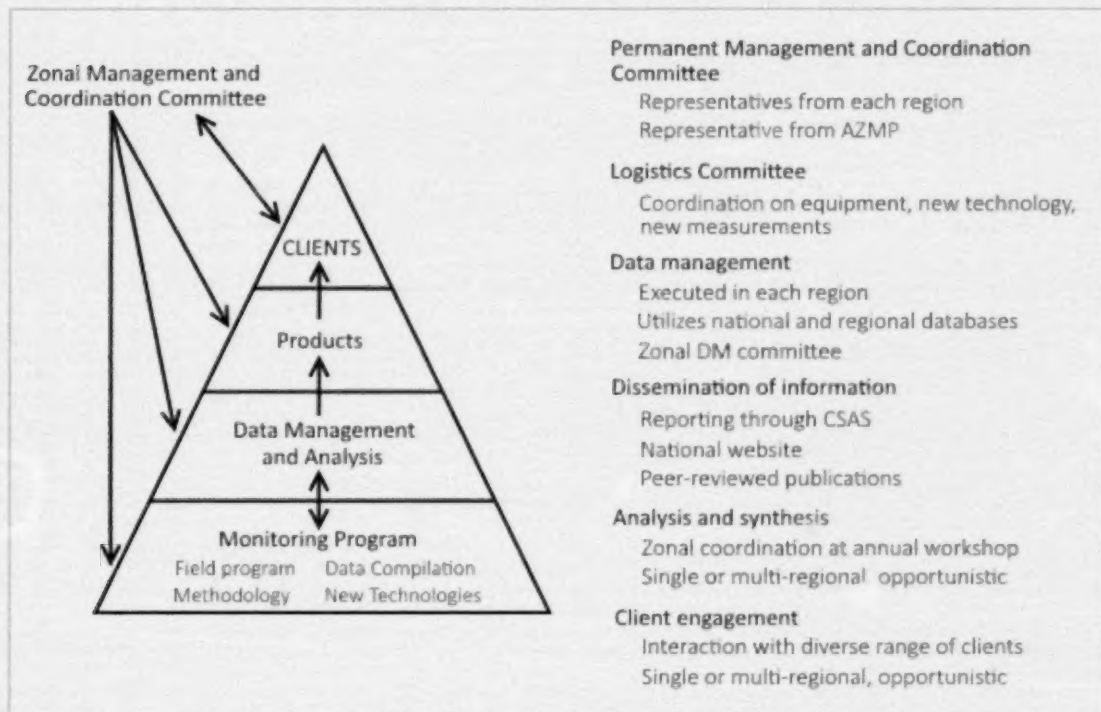


Figure 3. Schematic overview of the organizational structure of the Atlantic Zone Monitoring Program (AZMP) (left, modified from Therriault et al. 1998) and program elements providing inter-regional (i.e., zonal) coordination (right).

STM 1A: Provide recommendations for a DFO Maritimes coastal monitoring program (this report)

Advice in this report was developed using a literature review, initiation of the DFO Maritimes Coastal Monitoring Inventory, consultations and a workshop with coastal researchers, managers, and stakeholders to examine the past and current state of coastal monitoring in the Maritimes Region. Key papers on coastal and ocean shelf monitoring (Therriault et al. 1998; Strain and Macdonald 2002; COMNAP 2005; NROC and NERACOOS 2016) were reviewed as a foundation for developing the key elements of successful coastal monitoring programs, informing program milestones, and identifying discussion points for consultations and the workshop. Information was then collated and summarized into three sections in this report: a preliminary framework, key elements and program milestones, and general recommendations.

STM 1B: Establish a steering committee responsible for developing a strategic plan and founding documents

A steering committee composed of coastal research scientists should be established to develop a short-term strategic plan for coordinating and enhancing existing observations and to establish founding documents that outline the program's mission and vision statements. The steering committee would also be responsible for developing program objectives (see Key Element 3), sampling protocols, and data management strategies (see Key Element 4) and provide direction for budget decisions to the program coordinator (STM 1C).

To incorporate guidance on emerging management issues and to provide an opportunity for feedback and program assessment (see Key Element 8), a client-based advisory board should also be developed. This advisory board, including resource managers (e.g., Oceans and Coastal Management Division) would be briefed on program progress to keep the program relevant to client needs.

STM 1C: Initiate FTE support for program coordination

A program coordinator (full-time equivalent or FTE) should be identified to support efforts to bring together existing observations into a more coordinated program under the steering committee. Responsibilities would include expanding the DFO Maritimes Coastal Monitoring Inventory (STM 2C) and supporting its analysis to identify information gaps, needs, and opportunities; coordinating potential partners within and external to DFO and organizing consultations and workshops (STM 3C); liaising with the steering committee, data managers, research scientists, resource managers, and external stakeholders; coordinating monitoring work; acting as the contact person for queries from research scientists, resource managers, and external stakeholders; coordinating reporting; and managing the budget.

STM 1D: Develop program governance

The steering committee should develop the organizational structure of the program with consideration of program scale (regional, inter-regional, national) and participants (DFO, non-DFO). Elements of governance include annual work planning and deliverables (e.g., timing and venue of reporting) and processes for making decisions regarding new observations and program buildout. See Figure 3 for sample program structure of AZMP.

MTM 1: Coordinate with coastal monitoring initiatives in other DFO Regions

The 2016 Federal Budget supports further ocean monitoring and research activities across Canada and coordinating monitoring activities among regions will ensure comprehensive spatial and temporal coverage and consistent and complementary sampling designs, sampling protocols, and data management strategies.

KEY ELEMENT 2: SUPPORT FOR PROGRAM DEVELOPMENT AND SUSTAINED OBSERVATIONS

Sustained observations require stable, long-term support to achieve program milestones and meet program objectives. Personnel (FTEs), operational funding (A-base), and capital (instruments, lab equipment) are required to develop the program, deploy new observations, and implement the program on an ongoing basis. Whereas new observations may require additional resources, expansion of existing monitoring programs can provide a foundation for initial program development.

STM 2A: Initiate DFO Maritimes Coastal Monitoring Inventory (*this report*)

In October 2015, the DFO Maritimes Coastal Monitoring Inventory was initiated to assess the status quo of coastal monitoring and research in the region and to begin to identify gaps, needs, and opportunities (see Preliminary Framework: Gaps, Needs, and Opportunities). It was developed in parallel with the Integrated Sentinel Monitoring Network for Change in Northeast U.S. Ocean and Coastal Systems inventory (ISMN) hosted by the Northeast Regional Association for Coastal Ocean Observing Systems (NERACOOS) (NROC and NERACOOS 2016) (www.neracoos.org/sentinelmonitoring/database). The inventory is a key resource for communicating and coordinating past and present monitoring activities and is intended to be a living database. It should continue to be expanded (STM 2C) and ultimately made available online either as an independent database or integrated with ISMN (STM 4C). There are currently 55 records of previous or existing programs in Canada that either monitor the coastal zone or conduct research in the coastal zone (see examples in Table 3).

STM 2B: Identify budgetary support for program development, initiation, implementation, and maintenance

An assessment of existing or new FTEs, Operations and Maintenance (O&M), infrastructure, and sampling platforms available to a coastal monitoring program should be undertaken by coastal monitoring personnel.

STM 2C: Expand DFO Maritimes Coastal Monitoring Inventory

The DFO Maritimes Coastal Monitoring Inventory (initiated in STM 2A) should be expanded by the program coordinator (STM 1C) to include additional past and ongoing programs in the Maritimes Region. A more comprehensive view of all monitoring activities is crucial for assessing gaps, needs, and opportunities effectively during consultations and workshops with research scientists, resource managers, and stakeholders (see STMs 3A and 3C). An expanded inventory would support efficient planning, maximize spatial and temporal coverage of observations, and maximize the value of current programs and platforms (i.e., by identifying and prioritizing requirements to rescue and recover data and metadata, informing partners and clients of available data based on inventory metadata).

Table 3. Examples of ongoing monitoring and research efforts in Atlantic Canada from the DFO Maritimes Coastal Monitoring Inventory.

Name	Jurisdiction	Start	End	Variables sampled	Data publicly available?
DFO Aquatic Invasive Species (AIS) Monitoring Program	DFO	2005	ongoing	distribution and spread of AIS in high-risk areas	partially
Atlantic Zone Monitoring Program (AZMP)	DFO	1998	ongoing	temperature, salinity, nutrients, chlorophyll, dissolved oxygen, phytoplankton, zooplankton	yes
Bedford Basin (Plankton) Monitoring Program	DFO	1992	ongoing	temperature, salinity, nutrients, chlorophyll, dissolved oxygen, particulate organic carbon and nitrogen, bacteria, picoeukaryotes, phytoplankton, zooplankton	yes
Long-term Temperature Monitoring Program (LTTMP)	DFO	1978	ongoing	temperature	partially
Nova Scotia Aquaculture Environmental Monitoring Program (EMP)	Nova Scotia Department of Fisheries & Aquaculture	2002	ongoing	sediment sulfide concentration, oxidation-reduction potential, porosity, particulate organic matter sediment colour, microbial presence, macrofaunal assemblage	no

STM 2D: Initiate new monitoring via existing program expansion and pilot projects

Basic monitoring of fundamental variables (i.e., temperature, salinity) should be initiated across all coastal monitoring sub-regions (see Preliminary Framework: Representative Sub-regions) as soon as possible while the steering committee develops program objectives (see Key Element 3), sampling protocols, and data management strategies (see Key Element 4). Where possible, this should occur as enhancements of existing programs (e.g., LTTMP, DFO AIS Monitoring Program, Nova Scotia Aquaculture Environmental Monitoring Program; see Table 3) to maximize existing support (FTEs), expertise (instrument deployment and recovery, instrument calibration and field maintenance), and capital resources (e.g., data loggers). Pilot projects for specific indicators or priorities (e.g., expansion of shore-based observations to account for offshore monitoring gaps and priorities) may also be initiated as resources allow.

STM 2E: Identify new high-priority monitoring observations

Monitoring to address prioritized drivers and pressures (see Preliminary Framework: Drivers, Pressures, and Indicators) should be considered for long-term monitoring (e.g., ocean acidification, biodiversity loss) in addition to fundamental high-priority indicators (STM 2D). This includes developing standardized methodologies and sampling protocols using existing resources where possible (e.g., ISMN, AZMP). For example, ISMN provides peer-reviewed, standardized methodologies for measuring indicators. Monitoring indicators for each sub-region should be assessed in support of ongoing research (e.g., climate change trends and projections) and resource management (e.g., lobster stock assessment) with direct input from resource managers (e.g., MPA and EBSA planning and management). Identifying and collecting appropriate data in the short to medium term may also be sufficient to reassess coherence among coastal monitoring sub-regions and help refine long-term monitoring sites and activities. Further discussion of issues related to program development is summarized in the preliminary framework.

KEY ELEMENT 3: SHORT- AND LONG-TERM PROGRAM OBJECTIVES

Program objectives that are achievable, meaningful to a wide range of stakeholders (e.g., government, scientific community, public), and easily communicated for reporting and data management purposes are integral to a coastal monitoring program. Operational objectives should be relevant for the region being monitored and the specific goals of the program developers and stakeholders. Examples of specific objectives include tracking and predicting changes in productivity and ocean state, responding to immediate questions posed by clients, alerting clients to short- and long-term environmental or ecosystem changes, and providing adequate historical databases to address future issues (Therriault et al. 1998). Developing program objectives requires extensive collaboration in the form of initial and ongoing input from coastal research scientists and resource managers to identify key drivers and pressures on the ecosystem as well as current and future information requirements to address questions of common interest.

STM 3A: Initiate consultations and workshops with coastal research scientists, resource managers, and stakeholders (this report)

From October to December 2015, initial consultations were held with individuals and organizations that conduct or have previously conducted ocean or coastal monitoring and research in the Maritimes Region, including DFO monitoring programs, DFO researchers, DFO managers, community-based monitoring groups, municipal governments, non-profit organizations, and university groups (see Appendix 2 for participant list). Consultation questions addressed definitions of key terms, program objectives, program development, and potential challenges as well as the participants' engagement in coastal monitoring activities and their concerns and vision for a DFO Maritimes coastal monitoring initiative (see Appendix 3 for consultation questionnaire).

This preliminary input provided a foundation for facilitated discussions with consultation participants and others in a workshop in February 2016 (see Appendix 4 for workshop Terms of Reference and Appendix 5 for participant list). DFO was represented by AZMP Science Committee members as well as research scientists and managers from five divisions in the Maritimes region: Coastal Ecosystem Science Division (CESD), Ocean Ecosystem Science Division (OESD), Ocean Data and Information Services (ODIS), Population Ecology Division (PED), and Oceans and Coastal Management Division (OCMD). The diversity of perspectives and roles in a future coastal monitoring program reflected in this broad range of workshop participants provided a strong starting point for developing program objectives. During the workshop, initial options for program boundaries and representative sub-regions, key drivers, pressures, and indicators, and tools and techniques to address the indicators (see Preliminary Framework) were all discussed. Further workshops are critical to program development and recommended themes are proposed in STM 3C.

STM 3B: Develop short- and long-term program objectives

Objectives should be developed by the steering committee (STM 1B) using the committee's collective understanding of prioritized drivers and pressures (see Table 2). Support for these decisions should be based on the preliminary framework in this report and further consultations and workshops (see STM 3C) to provide guidance on identifying priority pressures in the environment and appropriate indicators that link to current and future research and resource management needs.

STM 3C: Continue consultations and workshops with coastal research scientists, resource managers, and stakeholders

Consultations and workshops (STM 3A) should be an iterative process to ensure that the program grows adaptively as priorities change and that observations and analyses are increasingly relevant to client needs. An effective and valuable coastal monitoring program should engage and support the needs of research scientists, resource managers, and stakeholders working or conducting research in the coastal zone (e.g.,

aquaculture; AIS; habitat management and conservation; energy resource development and management).

The next consultation stage should be organized by the program coordinator and steering committee to review and establish consensus on the preliminary framework in support of program objectives established by the steering committee. The steering committee should utilize further consultations to help develop the current and future role of the program and identify how all participants, clients, and stakeholders can collectively benefit from the program. Consultations should integrate perspectives from coastal research scientists and resource managers, NGOs, and universities working on fundamental topics and ecosystem components (e.g., benthic habitat health, AIS, biodiversity, aquaculture) as well as First Nations and the public to incorporate traditional ecological knowledge.

Two workshop themes are proposed here in support of program development. Workshop participants should include active and engaged coastal research scientists that will help drive coastal monitoring work (see STM 5A).

Theme 1: Identifying goals for coastal monitoring

- Define key drivers, pressures, indicators, and variables
- Establish a sampling design (i.e., what are appropriate temporal and spatial scales)
 - Use expanded Coastal Monitoring Inventory to identify existing datasets and identify gaps and omissions (i.e., where have we done well and where not)
- Establish an overarching strategy (i.e., for DFO Maritimes program integration and DFO regional collaboration)

Theme 2: Integrating coastal monitoring with other programs

- DFO Maritimes program integration (i.e., AIS, LTTMP)
- DFO regional collaboration and cooperation
- Non-DFO collaboration/cooperation (NGOs, community science, universities)

KEY ELEMENT 4: SUPPORT AND INFRASTRUCTURE FOR DATA MANAGEMENT

Data management elements (i.e., archival, quality assurance (QA) and quality control (QC), discoverability, access) maximize the value of invested resources in a monitoring program. Effective data management requires both infrastructure (e.g., databases, computing platforms, storage) and personnel (FTEs), which should be identified as early as possible through consultation with data managers, using existing resources where possible. Early involvement of data managers is critical to ensuring standardization and longevity of the program. Databases should also be regularly monitored and utilized by program management and research scientists to keep them relevant.

STM 4A: Develop data management plan for existing observations and identify budgetary support

Data management plans ensure that observations are properly measured, recorded, and reported. An initial data management plan should be developed to include QA/QC of data and metadata, an archiving management strategy, and basic data and metadata access by internal and external clients. Data management requirements and existing resources (FTEs and infrastructure) to accommodate existing coastal time series observations and pilot projects should be identified by the steering committee in consultation with ODIS, division data management liaisons, and existing long-term monitoring programs (e.g., AZMP).

STM 4B: Develop data management plan for new observations

Data management requirements and existing resources (FTEs and infrastructure) to accommodate new observations (STM 2E) should be identified by the steering committee with ODIS and division data management liaisons. Initial internal support within divisions and regionally is critical and proactive planning is required to secure the necessary resources in an appropriate timeframe. Data management plans at this stage should be more robust than they were during program initiation (STM 4A) and focused on medium- and long-term needs such as data serving and making data internally and externally accessible by e-mail request through data managers or self-serve portals.

STM 4C: Publish DFO Maritimes Coastal Monitoring Inventory online

The DFO Maritimes Coastal Monitoring Inventory (STM 2A) should be made available online to ensure existing datasets are discoverable. A new DFO site could be developed for the inventory or it could be served by the NERACOOS regional sentinel monitoring database developed for ISMN (www.neracoos.org/sentinelmonitoring/database).

KEY ELEMENT 5: SUSTAINED ENGAGEMENT OF RESEARCH SCIENTISTS IN DATA ANALYSIS AND SYNTHESIS

Long-term collaboration and communication among those with expertise in coastal ecosystem components is critical to identify research gaps, understand implications of environmental pressures on the ecosystem, and analyze and interpret observations to create useful knowledge. Engaged research scientists help ensure that collected data are available to the broader research community to support informed decision-making. Researchers provide high-level QA/QC, including feedback that supports coherent databases. Engagement of research scientists is also integral to develop reporting strategies (Key Element 6), promote communication and collaboration (Key Element 7), and conduct program assessments (Key Element 8).

STM 5A: Identify core group of research scientists

A core group of coastal research scientists (including members of the steering committee) who will integrate monitoring data into their research programs and contribute to coastal monitoring through planning and reporting activities should be identified to increase program engagement and inclusivity. Researchers with broad interests that will both contribute to the program (e.g., data, QA/QC, instrumentation, standardized sampling protocols) and benefit from the program (e.g., data, data products) would help ensure that the program will build relevance and thrive in the long term. This may be modelled after the AZMP, which has a core group of research scientists who work on research and monitoring activities in the continental shelf ecosystem. Researchers are engaged in the monitoring program and support clients and stakeholders via reporting and integrating client feedback into data management strategies.

STM 5B: Develop data products

Value-added data products (e.g., indicators) may be more useful than raw monitoring observations to clients and stakeholders, especially high-level managers and external clients. Development of data products requires commitment from research scientists to lead data analysis and interpretation and to work with resource managers to contextualize key environmental and management issues and communicate with stakeholders (see Key Element 7).

MTM 5: Identify support for data analysis and synthesis

New and existing FTEs should be identified to support data analysis, modelling work, and to publish reports in coordination with existing ODIS personnel and DFO Maritimes Divisional data managers (i.e., AZMP data management by OESD; AIS and LTTMP data management by CESD).

KEY ELEMENT 6: REGULAR, CREDIBLE, AND CLEAR PROGRAM REPORTING

Regular reporting of observations and key findings supports long-term success of coastal monitoring programs. Multi-regional annual reporting requirements (e.g., AZMP) provide integrated information on the state of the environment. Annual assessments of progress toward and requirements for ongoing program objectives should also be regularly documented (e.g., Canadian Science Advisory Secretariat (CSAS) proceedings) to ensure peer-reviewed, up-to-date information is available for assessing the program against its objectives.

STM 6: Establish program reporting goals

Clear and tangible reporting goals should be developed with coastal research scientists and resource managers to identify and focus monitoring efforts on current and future needs (5 to 10 years). Reporting goals should be scientifically, technologically,

logistically, and financially achievable to provide a good tool to assess the program in the future (see Key Element 8).

MTM 6: Initiate peer-reviewed program reporting

Peer-reviewed program reporting (e.g., CSAS) should be coordinated by the program coordinator (STM 1B) and developed by the core group of coastal research scientists (STM 5A). Plain-language public reporting of results (see Key Element 7) should be included in program reporting.

KEY ELEMENT 7: COMMUNICATION AND COLLABORATION AMONG RESEARCH SCIENTISTS, RESOURCE MANAGERS, AND STAKEHOLDERS

Many groups and organizations work in the coastal ecosystem and all should be involved in the coastal monitoring program to encourage coordinated efforts. Data products and plain-language annual reporting available online are an important program element as these products engage the science community and public and encourage collaboration. This is particularly important for the coastal zone given access and visibility of this habitat.

STM 7: Develop and implement a communication plan

A communication plan to coordinate information exchange between research scientists and stakeholders should be developed by the program coordinator, who would liaise with the DFO communication group. The plan should include communication with all potential collaborators within and outside DFO Maritimes. Communication with non-DFO groups will enhance overall collaboration, increase utility of data, and help raise the profile of DFO monitoring efforts with limited additional effort. Long-lasting benefits for all clients will support the development of positive, complementary, and enduring working relationships.

MTM 7: Establish program website

A website should be the public's main portal of information regarding a coastal monitoring program and should provide program mission statement and objectives, resources, updates, and data products to scientists and stakeholders.

KEY ELEMENT 8: PERIODIC ASSESSMENT OF THE PROGRAM

Regular assessment and review of program objectives (e.g., every 3 to 5 years) contributes to the long-term success of coastal monitoring programs. The process should use an adaptive management approach to allow the program focus to shift as pressures on the coastal zone and monitoring priorities change. Discussion among research scientists and coastal managers from within and outside the program help ensure that goals are being met and that appropriate questions are being asked.

MTM 8: Assess progress and re-evaluate program requirements

Progress should be assessed periodically (e.g., every 5 years) by the steering committee with input from the advisory board (see STM 1B) using CSAS reporting as a foundation for re-evaluating program objectives.

GENERAL RECOMMENDATIONS

An effective and valuable coastal monitoring program should engage and support the needs of research scientists, resource managers, and stakeholders working or conducting research in the coastal zone (e.g., aquaculture; AIS; habitat management and conservation; energy resource development and management). Optimizing monitoring in the coastal zone with a coastal monitoring program would require DFO to coordinate work by government, universities, NGOs, and other stakeholders to develop baseline observations and identify data most relevant to research scientists and resource managers. With additional coordination, the value of observations made by existing coastal monitoring programs and the platforms these programs provide could also be substantially enhanced. Support for coastal monitoring coordination, direction from a steering committee, and coastal data management processes are necessary to provide the infrastructure required to efficiently add new coastal observations and incorporate them into data management, data analysis, and advice.

Based on the above criteria, and in consideration of the work generated as part of this report, seven milestones were identified for immediate action in support of further development of a DFO Maritimes coastal monitoring program (Table 4). Recommendations are weighted towards planning and establishing governance and support, which is the critical foundational work that will optimize future monitoring efforts within and outside of DFO and ultimately determine the success of the program (see AZMP as an example of a successful monitoring program with strong governance, planning, and support). All recommendations are meant to be implemented by managers as an integrated collective, whereby expanding existing resources (i.e., DFO Maritimes Coastal Monitoring Inventory) and integrating/complementing existing programs (i.e., LTTMP, DFO AIS Monitoring Program) can begin to generate new data as program objectives are developed through further consultations and workshops.

There is currently opportunity and interest in establishing a DFO Maritimes coastal monitoring program. The preliminary framework, key elements and milestones, and general recommendations in this report aim to provide a foundation and vision for development of a regional framework (possibly national framework in collaboration with other regions) through consultation with DFO experts and prospective users to optimize current and future monitoring efforts and generate valuable data and data products.

Table 4. STMs selected as key recommendations for immediate implementation by managers of a DFO Maritimes coastal monitoring program.

Building a foundation	
1. STM 1B	Establish a steering committee responsible for developing a strategic plan and founding documents
2. STM 1C	Initiate FTE support for program coordination
3. STM 2B	Identify budgetary support for program development, initiation, implementation, and maintenance
4. STM 3B	Develop short- and long-term program objectives
Stabilizing existing resources	
5. STM 2C	Expand DFO Maritimes Coastal Monitoring Inventory
6. STM 3C	Continue consultations and workshops with coastal research scientists, resource managers, and stakeholders
Growing the program	
7. STM 2D	Initiate new monitoring via existing program expansion and pilot projects

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APPENDIX 1: DRIVERS AND PRESSURES IN THE MARITIMES REGION COASTAL ZONE

Potential indicators to monitor prioritized coastal pressures under three drivers: climate change, coastal development, and coastal pollution, as identified by three breakout groups at the Coastal Monitoring Workshop.

Climate Change

Rank	Pressure	Indicators	Sampling Frequency	Source of Support	Existing Monitoring Efforts or Programs	Comments
1	Warming temperatures	Temperature	Continuous, seasonally	Existing program Coordination between groups; DFO investment	LTTMP; FSRS	DFO investment can expand LTTMP
2	Ocean acidification and pH	pH	Daily, weekly, monthly	Coordination between groups; DFO investment	GOA-ON	Will require DFO investment, including equipment (reliability of equipment will require testing; short-term R&D expectations)
3.5 (tie)	Salinity	Salinity	Continuous, daily, weekly, monthly	Existing program; Coordination with other programs	DFO AIS Monitoring Program; ECCC; CIS	Salinity can be monitored with temperature simultaneously
3.5 (tie)	Sea level rise (including storm surges)	Sea level	Daily, weekly, monthly	Coordination with other programs	CHS; ACCASP	Opportunity for community involvement and building partnerships with community groups, as sea level height measurements are easy to take
5	Ice cover	Ice cover	Daily, weekly, seasonally	Coordination with other programs	ECCC; CIS	Will be a high priority indicator in some regions (e.g., Gulf)

ACCASP—Aquatic Climate Change Adaptation Services Program; AIS—aquatic invasive species; CHS—Canadian Hydrographic Service; CIS—Canadian Ice Service; ECCC—Environment and Climate Change Canada; FSRS—Fishermen Scientists Research Society; GOA-ON—Global Ocean Acidification Observing Network; LTTMP—Long-term Temperature Monitoring Program

Coastal Development

Rank	Pressure	Indicators	Sampling Frequency	Source of Support	Existing Monitoring Efforts or Programs	Comments
1	Habitat or biodiversity loss and degradation	Species richness (pelagic and benthic); Substrate (loss or change); Benthic community structure or plankton composition; Sentinel species	Periodic, every 5–10 years	Coordination with other programs; DFO investment	OCMD; CAMP	DFO's Ocean and Coastal Management Division (OCMD) identifying EBSAs and MPA network planning; Opportunity for community involvement and partnerships with community groups; Will require significant DFO investment, including equipment and FTEs
2	Aquatic invasive species (AIS)	Species richness and abundance	Seasonally, annually	Existing program; DFO investment	DFO AIS Monitoring Program (CESD)	DFO investment may help to expand coverage or scope of existing program
3.5 (tie)	Water quality (including turbidity)	Bacterial composition; Turbidity and TSS; Nutrients; Dissolved oxygen; BOD; Contaminants	Daily, weekly, monthly, seasonally	Existing program; Coordination with other programs; DFO investment	CSSP; ACCASP; EMP	DFO investment can expand existing programs
3.5 (tie)	River inflow, sedimentation and erosion processes, and sediment transport	Turbidity; Sediment distribution; Sedimentation rate; Habitat biodiversity	Annually, twice-decadal	Existing programs; Coordination with other programs	CESD's benthic ecology group; SRA	Will require DFO investment, including FTEs for mapping habitats, lab analysis, etc.
5	Industrial use; coastal development urbanization	Percent coverage of area occupied; Water quality; Vessel traffic (patterns and density)	Annually	Existing programs; Coordination with other programs	Province of Nova Scotia; Municipalities; Harbour/Port Authorities	Provinces map urbanization and development trends

ACCASP—Aquatic Climate Change Adaptation Services Program; AIS—aquatic invasive species; CAMP—Community Aquatic Monitoring Program; CESD—Coastal Ecosystem Science Division; CSSP—Canadian Shellfish Sanitation Program; EBSA—Ecologically or Biologically Significant Marine Area; EMP—Nova Scotia Aquaculture Environmental Monitoring Program; OCMD—Oceans and Coastal Management Division; SRA—Sackville Rivers Association

Coastal Pollution

Rank	Pressure	Indicators	Sampling Frequency	Source of Support	Existing Monitoring Efforts or Programs	Comments
1	Eutrophication, dissolved oxygen, dead zones, and nutrient loading	Dissolved oxygen; Nutrients; Trophic interactions (i.e., changes to plankton composition); Turbidity; Denitrification; Light attenuation; Amount of nuisance algae	Annually for sites that have predictable patterns; Episodically and as reported for unpredictable sites	Coordination with other programs; DFO investment	Phytoplankton monitoring program in Bay of Fundy; HRM's water quality monitoring program; CSSP on nuisance algae; CBEMN	Will require significant DFO investment, including equipment and FTEs (e.g., lab support for nutrient analyses)
2	Runoff-mediated effects	Bacterial composition (especially <i>E. coli</i>); Nutrients; Debris in water	Periodically (monthly or episodically after major precipitation events)	Coordination with other programs; DFO investment	HRM's water quality monitoring program	Closely linked with eutrophication and water quality; DFO investment may be required should nutrient analyses be utilized
3	Contaminants (including oil spills)	Oil slicks	Episodically	Existing programs	ECCC	Needs to be clear which organization is responsible (ECCC, DFO, CFIA, etc.)
4	Pathogens and disease	Bacterial activity (e.g., <i>E. coli</i>)	Seasonally, annually	Existing program; DFO investment	CSSP	CSSP tracks bacterial activity to an extent; DFO investment could help expand CSSP
5	Marine debris (including microplastics)	Visual surveys; Sieving; Microplastic concentrations	Annually	Coordination with other groups or programs	Friends of McNabs Island Society; WWF	Opportunity to collaborate with citizen science and community-based groups

CBEMN—Community-Based Environmental Monitoring Program (St. Mary's University); CFIA—Canadian Food Inspection Agency; CSSP—Canadian Shellfish Sanitation Program; ECCC—Environment and Climate Change Canada; HRM—Halifax Regional Municipality; WWF—World Wild Fund for Nature

APPENDIX 2: PARTICIPANTS IN PRE-WORKSHOP CONSULTATIONS

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CESD—Coastal Ecosystem Science Division; FSRs—Fishermen Scientists Research Society; GAMS—Gulf Aquarium and Marine Station Cooperative; HRM—Halifax Regional Municipality; OESD—Ocean Ecosystem Science Division; PED—Population Ecology Division; SABS—St. Andrews Biological Station

APPENDIX 3: QUESTIONS USED TO GUIDE CONSULTATIONS (OCT–DEC 2015)

Background

1. Do you agree with the following definitions? If not why?
 - *Coastal* – the seaward limit of the coastal zone is the inshore limit of both the Atlantic Zone Monitoring Program (AZMP) and the DFO Research Vessel Trawl Survey (ca. 12 nm offshore or 100 m in depth); the landward limit is the high-water mark (Greenlaw et al. 2012).
 - *Monitoring* – the minimal, ongoing collection and analysis of ocean data required to obtain a quantitative description leading to an understanding of the variability of the biological, chemical, and physical characteristics of a particular region to invoke a prescribed response to help mitigate the condition's cause or its impacts (after Therriault et al. 1998; Strain and Macdonald 2002).
2. What are the major threats to coastal ecosystem/ocean health that a monitoring system should target?

Monitoring–Specific

3. Describe any coastal monitoring activities that you conduct or participate in presently.
4. Describe any coastal monitoring activities that you are planning or would like to conduct in the future.

For questions 3 and 4, consider the following:

- a. Prioritize preferred monitoring variables/indicators.
 - i. Biological
 - ii. Chemical
 - iii. Physical
- b. How frequently should variables/indicators be monitored?
- c. Where should these variables be monitored?
 - i. Nearshore (within 10 km from shore)
 - ii. Exposed coast (within 1 km from shore)
 - iii. Estuarine
- d. What time frame would make the above monitoring useful (e.g., 5, 10, 15 yrs., etc.)?
- e. What will coastal monitoring data/products be used to address? For example,
 - i. Scientific questions?
 - ii. Predictions/projections (e.g., climate change impacts)?
 - iii. Integrated analyses (e.g., collaborations with other programs, etc.)?

Monitoring–General

5. Describe PAST and CURRENT short- and/or long-term coastal monitoring efforts in your region by the following categories:
 - a. Federal government (e.g., DFO, AZMP, AIS, etc.)
 - b. Provincial government (e.g., AIS, etc.)
 - c. Academia (e.g., CAISN I, CHONe, MEOPAR, etc.)
 - d. NGOs, ENGOs (e.g., FSRS)

- e. Community groups
- f. Industry (e.g., aquaculture)

For question 5, are you aware of or able to access

- a. Data?
- b. Data products?
- c. Sampling protocols?

Challenges and Concerns

- 6. To your knowledge, have any monitoring programs (or aspects of those monitoring programs) been cancelled or lost funding in your region?
- 7. What do you view as the general shortcomings of current monitoring programs?
- 8. What do you view as the biggest challenges to coastal monitoring in your region (e.g., jurisdictional challenges (federal vs. provincial), organizational challenges (e.g. departmental responsibilities/leads), funding, interest, etc.?

Conclusions

- 9. Any additional thoughts on your vision (short- or long-term) for a coastal ocean monitoring framework?

APPENDIX 4: TERMS OF REFERENCE FOR COASTAL MONITORING WORKSHOP

16-18 February 2016

Fisheries and Oceans Canada, Maritimes Region
Bedford Institute of Oceanography, Dartmouth, NS

Background

Canada has the longest coastline in the world, and many citizens depend on the oceans for livelihood and recreation: thus, maintaining the health of Canada's coastal ocean ecosystems is a crucial task.

Monitoring ocean conditions is the basis upon which all Fisheries and Oceans Canada (DFO) Ocean Science activities are built, and it is critical in identifying drivers, pressures, and impacts that are causing environmental damage and change (Strain and Macdonald 2002). Coastal ecosystem monitoring is challenging for a variety of reasons, including limited long-term funding opportunities, dynamic coastal conditions, and heterogeneous coastal ecosystems. Typically, monitoring is conducted via data collection and interpretation of key indicators that are considered to reflect overall ecosystem health. However, given limited resources, prioritizing indicators and identifying appropriate temporal-spatial scales of a monitoring program is a challenging exercise.

Many institutions and organizations, including federal, provincial, and municipal governments, community groups, non-governmental organizations, universities, and industries are currently conducting (or have previously conducted) aspects of coastal monitoring. To date, however, there is no comprehensive coastal ecosystem monitoring strategy in Canada.

DFO Maritimes' Coastal Ecosystem Science Division (CESD) is developing options for a coastal monitoring program. To date, an inventory of past and current coastal monitoring programs has been initiated, and in-person consultations with various groups (e.g., DFO scientists (retired and current), DFO managers, community groups, municipal governments, non-profit organizations, academic groups) have been conducted to survey opinions relating to coastal monitoring; topics discussed during the consultations can be found in Appendix 3. CESD is now ready to bring coastal ecosystem researchers together for broader interactive discussions in the form of a Coastal Monitoring Workshop.

Objectives

The overarching objective of the coastal monitoring workshop is to define the minimum requirements necessary to establish a coastal monitoring program.

The overarching objective will be met by addressing the following working objectives:

1. Identify options to enhance scientific community support for an integrated and coordinated monitoring network

- Review existing monitoring efforts (e.g., ISMN, AZMP, CBEMN)
 - Identify monitoring strategies to ensure adequate spatial and temporal coverage
2. Review representative coastal zonation (i.e., Greenlaw et al. 2012)
 - Identify geographic extent of the coastal zone
 - Identify representative coastal zonation for target monitoring
 3. Prioritize key drivers and pressures of coastal monitoring
 - Review drivers and pressures identified during consultations
 - Identify any missing drivers or pressures not listed
 - Rank drivers that pose the biggest threat to coastal ecosystems
 - Rank pressures that pose the biggest threat to coastal ecosystems
 4. Identify pressure-specific indicators
 5. Identify appropriate states and indicators, specific to drivers and pressures identified above, required for a coastal monitoring program
 6. Identify temporal-spatial aspects of a coastal monitoring program
 - Identify indicator sampling timelines (e.g., temporal-spatial frequency, continuous vs. periodic sampling, replication, etc.)

Expected Publications

The advice generated from background research, consultations with stakeholders, and the Coastal Monitoring Workshop will be published as a Canadian Technical Report of Fisheries and Aquatic Sciences.

Participation

Most participants at the Coastal Monitoring Workshop are public servants with DFO from the Quebec (IML), Newfoundland (NWAFC), and Maritimes Regions (BIO and SABS). DFO Divisions represented from the Maritimes Region include Coastal Ecosystem Science (CESD), Ocean Ecosystem Science (OESD), Ocean Data and Information (ODIS), Population Ecology (PED), and Oceans and Coastal Management (OCMD).

Non-public servant participants include individuals from academic institutions, not for profit and community-based organizations, and international non-governmental organizations.

References

- Strain, P.M. and Macdonald, R.W. 2002. Design and implementation of a program to monitor ocean health. *Ocean Coast. Manage.* 45: 325-355. DOI:10.1016/S0964-5691(02)00074-1

APPENDIX 5: PARTICIPANTS IN COASTAL MONITORING WORKSHOP

Name	Title & Affiliation
DiBacco, Claudio (<i>Chair</i>)	Research Scientist, DFO Maritimes – CESD
Scriven, Danielle (<i>Coordinator</i>)	Aquatic Science Biologist, DFO Maritimes – CESD
Azetsu-Scott, Kumiko	Research Scientist, DFO Maritimes – OESD
Bryce, Daniel	Marine Coastal Planner / GIS Officer, Nova Scotia Department of Fisheries and Aquaculture
Cogswell, Andrew	Physical Scientist, DFO Maritimes – OESD
Cook, Adam	Aquatic Science Biologist, DFO Maritimes – PED
Cooper, Andrew	Research Scientist, DFO Maritimes – CESD (SABS)
Drozdowski, Adam	Physical Scientist, DFO Maritimes – CESD
Galbraith, Peter	Research Scientist, DFO Quebec – Pelagic and Ecosystem Science Branch
Greenlaw, Michelle	Benthic System Biologist, DFO Maritimes – PED
Horne, Ed	Research Scientist, DFO Maritimes – CESD
Johnson, Catherine	Research Scientist, DFO Maritimes – OESD
Law, Brent	Physical Scientist, DFO Maritimes – CESD
Lawton, Peter	Research Scientist, DFO Maritimes – CESD (SABS)
Nasmith, Leslie	Aquatic Science Biologist, DFO Maritimes – PED
Niven, Sherry	Manager, OESD, DFO Maritimes
Noyes-Hull, Gretchen	President, GAMS; Adjunct Professor, University of Maine at Augusta
Page, Fred	Research Scientist, DFO Maritimes – CESD (SABS)
Parlee, Kathryn	Senior Analyst, Ecosystems & Health of the Oceans, ECCC
Pepin, Pierre	Research Scientist, DFO Newfoundland – Science, Oceans and Environment: Biological and Physical Oceanography Section
Redden, Anna	Associate Professor, Department of Biology, Acadia University; Director, Acadia Centre for Estuarine Research; Director, Acadia Tidal Energy Institute
Spears, Tobias	Head, ODIS, DFO Maritimes
Wattie, Emma	Program Officer, Community Based Environmental Monitoring Network (Saint Mary's University)
Westhead, Maxine	Section Head, Protected Areas and Conservation Planning, DFO Maritimes – OCMD
Wong, Melisa	Research Scientist, DFO Maritimes – CESD

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